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# Gears in Morgan Shears

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TX *Shears - General*  
MORGAN CONSTRUCTION CO.  
ROLLING MILL DEPT. MEMORANDUM

TO: As Noted  
FROM: C. Conlon & M. Knott  
SUBJECT: Gears in Morgan Shears

DATE: 30 June 1971

*Marty: would you please add to your work list: "Study Log in shears" (pages 3 & 4)*

Discussion:

1. Problem

Recently the assembly floor had trouble with the crop and cobble shear for the Magma Copper Mill, general drawing 187714. The 58T gears on the crank shafts had no backlash at one point of turning, actually a slight bind, and had about .003 in. 180° around. The backlash called for was .005 in.. The upper gear was recut.

It was learned that this need to recut to obtain the called for backlash is not unusual.

2. Backlash

The ".005" is called for on all shear gears. Because it is difficult to obtain, the requirement has been reviewed. Only shears on order have been considered to-date. The ideas of this memo should be applied to all shears as they come on order.

a. .005" Backlash

The Acindar shear, order number 126062 and general drawing number 187477, will be used to illustrate the need for .005" backlash. The crank shafts are 30" apart, and the drive from one crank shaft to the other is thru four (4) 10" diameter gears. If the backlash is .005" at each mesh the possible variation in the circumferential gap between the two knife blades is:

$$3 \times .005 \times \frac{15}{5} = .045"$$

Originally the .005" was decided when a shear with a similar build-up of circumferential gap gave trouble. The .005" was thought to be practical for ground gears and was decided on. It requires:

Ground gears with tooth thickness held to .001".

Center distances held to  $\pm .001"$

Gear tooth runout held to about .003"/

Considering just these three tolerances, there is a possible variation in the backlash of the

	ACT	INF
HERMES		X
HILL		X
HOWARD		X
MARSTERS		X
MERCER		X
MORGAN, PA. S.		X
POOLE		X
RANDALL		X
WILSON		X
GEN. FILE		X
BERGSTROM		
Powers, L		X
CONLON		X
DUNCAN		
ERICKSON, A		
FONTAINE, H		
FONTAINE, R	X	
GILVAR		X
GRESHAM		
HEYL		
Ceminski, R		X
O'Coin, J.		X
HOMWOOD		
JACQUES, R.		
KINNICUTT		
KLUSMIER		
KNOTT		X
MAROTI		
MATHIEU		
MACPHERSON		
MCWILLEN		
MCNAUGHER		
MEIGS		
MORGAN, M		
NEELY		
ORDOG		
PLITNICK		
PRENTICE		
PROCTOR		
REARDON		
Mangini, N		X
ROBERTSHAW		
SIEURIN		X
VITELLI		
WIGINGTON		
MacNutt, H		X
WINTERS		
WOOD		
WRIGHTSON		X
WYKES R.	X	
YOUNG		
Prescott, W		X
ACCOUNTING		
PURCHASING		
MANUFACTURING		
Oso, R.		X
COMB CONTROL		
MORGILL		
WIRE DRAWING		
PITTSBURGH		



assembly gears of about .005".

$$\text{Backlash variation} = 2 \times \text{Tooth Variation} + 2 \\ (\text{C.D. Change} + \text{Runout}) \times \sin, \text{P.A.}$$

$$\text{Backlash Variation} = .002 + 2 (.002 + .003) \times .342$$

$$\text{Backlash Variation} = .0054 \text{ in.}$$

Other small contributors to backlash variation are bearing clearances, tooth profile errors, and tooth lead errors.

The backlash of the assembled gears can therefore easily go from .0025 to .0075 in.. The call for .005" backlash on the gear drawings calls for close tolerances. Actually shear 187477 has  $\pm .002$ " center distance variation on paper. In table I the desirable tolerances are listed.

b. .010" Backlash

The Acindar shear, order number 126060 and general drawing number 188513, is similar to many shears now on order. See Fig. 1. The crank shafts are 24" apart and the drive from one crank to the other is thru a pair of 24" gears. If the gear backlash is .005 in. the possible variation in the circumferential gap between the two blades is the same as the backlash, .005". This is quite a different situation, and the backlash value on this and similar shears has been increased to .010 in.

This requires:

Cut gears with tooth thickness held to .002".

Center distances held to  $\pm .002$ "

Gear tooth runout held to .005"

The possible backlash variation would be:

$$\text{Backlash Variation} = 2 \times .002 + 2 (.004 + .005) \times .342$$

$$\text{Backlash Variation} = .010 \text{ in.}$$

In Table I the suggested tolerance for the assembled gears is .005 to .015".

c. .015" Backlash

The Kennecott shear, order number 113020 and general order number 190010, is another type of shear. It is used for cutting the copper billets before the mill and the knife blades do not cover one another. They just come close to butting, end on end. Also the variation in circumferential gap is directly equal to the backlash. It has been decided that .015"

backlash is acceptable. In Table I the suggested tolerance for the assembled gears is .0075 to .0225".

3. Gear Manufacture

- a. The rule for the ".005 in." type shear is to hold the circumferential blade gap to a practical minimum. This can best be done by grinding the gears. This tooth grinding should be done with the gears mounted on their shafts.

For the ".010 in." type shears the gears can be cut. It is recommended that they be cut on their shafts.

For the ".015 in." type shears the gears can be cut. Whether or not the gears are cut on their shafts is optional. For the one shear reviewed, 190010, the gear drawing has been changed to cut the gears on their shafts.

- b. After the above manufacturing procedure was decided on, it was discovered by Manufacturing/Engineering that it is necessary to mount the bearing and cartridge at the knife end of the crank shaft before mounting the gear. Fig. 1 shows these parts in red for the Acindar shear 188513. This has been considered by Manufacturing and is acceptable. The advantage of cutting the gears on their shafts is wanted. In the future the possibility of arranging the shaft shoulders so that this preassembly of the bearing would not be necessary should be considered.

The manufacturing procedure would be:

1. Completely finish shaft with bearing and gear seats concentric within .001 T.I.R..
2. Mount bearing and cartridge. See Fig. 1
3. Shrink on gear. Pressing might bend the shaft.
4. Grind the sides of the gear square with the shaft journals as shown on the gear drawings.
5. Cut (or cut and grind) the gear teeth.

The masked bearing should be above when this is done.

4. Belgo Shears

The Belgo shears, M188710 and M188694, order numbers 125722 and 125724, require special attention. We are furnishing the innards for Siemag housings on site. The shears are the same type as Fig. 1. The bearings and cartridges at the blade end will be assembled before the gear cutting and will therefore be on the shaft and gear assemblies when they are shipped. The gear drawings ask for records on the gears, since we will not be checking the backlash on the assembly floor.



Belgo shear M188735 is similar to the Kennecott shear 190010. However it is smaller, faster, and cuts a much smaller product. For these reasons .010" backlash has been called for rather than .015".

Conclusions:

1. The gear backlash requirement should be reviewed for each shear as it comes on order.
2. Table I sums up the changes recommended for the shears now on order. These should be discussed. Further drawing changes are required because of the necessary pre-assembly of the bearing and cartridge.
3. To avoid preassembly of the crank shaft bearings at the knife end of the shaft, a change in the shaft shoulder arrangement should be considered for the future. ]

M. Knott

MK/1a

Additional cc: Dudley, R. (3)  
Gasper, W.  
Ostrom, J.  
McCormick, T.

TABLE I.

SHEARS ON ORDER	GEARS			Backlash Tol. for Assm. Gears	Center Distance Tolerance
	Manner of Manufacture	AGMA Class	Backlash		
Acindar 126060 - 188513	Cut gear on Shaft.	8	.010"	.005 to .015"	± .002"
Acindar 126062 - 187477	Grind gear on Shaft	11	.005"	.0025 to .0075	± .001"
Belgo 125722 - M188710	Cut gear on Shaft	8	.010"	.005 to .015"	± .002"
Belgo 125724 - M188694	Cut gear on Shaft	8	.010"	.005 to .015"	± .002"
Belgo 125727 - M188735	Cut gear on Shaft	8	.010"	.005 to .015"	± .002"
Kennecott 113020- 190010	Cut Gear. On Shaft is optional	6	.015"	.0075 to .0225	± .002"
Kennecott 113032- 190032	Cut gear on Shaft	8	.010"	.005 to .015"	± .002"
Szopienice 126143- M189767	Cut gear on Shaft	8	.010"	.005 to .015"	± .002"